



## Books & Reports

### Meteoroid/Orbital Debris Shield Engineering Development Practice and Procedure

A document describes a series of models created for the determination of the probability of survival of critical spacecraft components from particle strike damage caused by hypervelocity impact of meteoroids and/or orbital debris. These models were integrated with both shield design and hypervelocity impact testing to develop adequate protection of said components to meet mission survivability requirements.

Spacecraft configuration and construction were determined, including geometric shapes, dimensions, positions, material of construction, etc., for the spacecraft or component. The types and levels of damage allowable for each protected component were determined.

Critical damage was defined by the damage level that will cause loss of function of the protected component. Required probability of survival for the critical components was determined. This was done by determining the probability of survival based on exposure only, neglecting shielding. Next, a Monte Carlo simulation was run representing all possible particle impacts, collecting data on shielding-protecting components. An empirical physics-based model that estimates the incident kinetic energy required to cause critical damage to the component was applied to each Monte Carlo simulated particle strike.

*This work was done by James G. Zwitter and Marc A. Adams of Caltech for NASA's Jet Propulsion Laboratory. NPO-46082*

### Self-Balancing, Optical-Center-Pivot, Fast-Steering Mirror

A complete, self-contained fast-steering-mirror (FSM) mechanism is reported consisting of a housing, a mirror and mirror-mounting cell, three PZT (piezoelectric) actuators, and a counterbalance mass. Basically, it is a comparatively stiff, two-axis (tip-tilt), self-balanced FSM. Prior technology required two systems

back-to-back on a center bulkhead, employing six opposing actuators, which must then be electronically balanced and recalibrated from time to time. The present invention requires only three (or three pairs for flight redundancy) actuators. If a PZT actuator degrades, the inherent balance remains, and compensation for degraded stroke is made by simply increasing the voltage to the PZT. Prior designs typically do not pivot at the mirror optical center, creating unacceptable beam shear.

*This work was done by James D. Moore and Johnathan W. Carson of Caltech for NASA's Jet Propulsion Laboratory. NPO-45985*

### Wireless Orbiter Hang-Angle Inclinometer System

A document describes a system to reliably gather the hang-angle inclination of the orbiter. The system comprises a wireless handheld master station (which contains the main station software) and a wireless remote station (which contains the inclinometer sensors, the RF transceivers, and the remote station software). The remote station is designed to provide redundancy to the system. It includes two RF transceivers, two power-management boards, and four inclinometer sensors.

Power-management algorithms were developed and implemented to assure nominal system operation over the elapsed time between when the inclinometer system is installed at the orbiter processing facility (OPF), and the actual hang-angle measurement operation when the orbiter is brought up to a full vertical position in the vehicle assembly building (VAB). Relay and polling schemes were implemented to overcome any RF interference and power-management schemes, respectively. A set of unique algorithms was also developed to take full advantage of the redundancy of the system to meet the critical measurement requirements.

Several novel features of the wireless hang-angle inclinometer system are an ultra-low thermal expansion coefficient mounting bracket, housing the inclinometer sensors, to minimize errors caused by thermal expansion over the

wide temperature range; a power management software to monitor and conserve electrical energy of the batteries in the remote station; and an RF health check algorithm to verify/assure proper communication link between the remote station and the hand-held base station.

*This work was done by Angel Lucena, Jose Perotti, Eric Green, and Jonathan Byon of Kennedy Space Center; Bradley Burns, Carlos Mata, and John Randazzo of ASRC Aerospace Corporation; and Norman Blalock of Sierra Lobo, Inc. KSC-12751*

### Internal Electrostatic Discharge Monitor — IESDM

A document discusses an innovation designed to effectively monitor dielectric charging in spacecraft components to measure the potential for discharge in order to prevent damage from internal electrostatic discharge (IESD). High-energy electrons penetrate the structural materials and shielding of a spacecraft and then stop inside dielectrics and keep accumulating. Those deposited charges generate an electric field. If the electric field becomes higher than the breakdown threshold ( $\approx 2 \times 10^5$  V/cm), discharge occurs.

This monitor measures potentials as a function of dielectric depth. Differentiation of potential with respect to the depth yields electric field. Direct measurement of the depth profile of the potential in a dielectric makes real-time electronic field evaluation possible without simulations.

The IESDM has been designed to emulate a multi-layer circuit board, to insert very thin metallic layers between the dielectric layers. The conductors serve as diagnostic monitoring locations to measure the deposited electron-charge and the charge dynamics. Measurement of the time-dependent potential of the metal layers provides information on the amount of charge deposited in the dielectrics and the movement of that charge with time (dynamics).

*This work was done by Wousik Kim, Dan M. Goebel, Insoo Jun, and Henry B. Garrett of Caltech for NASA's Jet Propulsion Laboratory. NPO-47347*